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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Fourth Semester, B.E. - Industrial and Production Engineering

Semester End Examination; May/June - 2019

Engineering Thermodynamics

Time: 3 hrs *Max. Marks: 100*

Note: *Answer FIVE full questions, selecting ONE full question from each unit.*

UNIT - I

1 a. What do you understand by Microscopic and Macroscopic view points? With an example, explain which point of view is used to study engineering thermodynamics. 6

b. Explain with example Quasi-Static process and also write is characteristic feature. 8

c. State Zeroth law of thermodynamics. With a neat sketch, suggest the existence of a system property. 6

2 a. What is thermodynamic definition of work? Prove that work is a path function. 6

b. A mass of 1.5 kg of substance is compressed in a Quasi-Static process from 0.1 MPa to 0.7 MPa. The initial density of substance is 1.16 kg/m^3. Determine magnitude of workdone on substance;
i) If process is according to the law PV = constant
ii) If process is according to the law $PV^{1.4}$ = constant 6

c. A simple magnetic substance is one involving only magnetic displacement work i.e., a change in magnetization of the substance in the presence of a magnetic field. For such a substance undergoing a Quasi-Static process at constant volume. The displacement work is given by $\delta_w = -C_0 HdM$, where H = magnetic field intensity, M = Magnetization, C_0 = Proportionality constant. For a first approximation, assume that magnetization is proportional to the magnetic field divided by the temperature of the magnetic substance. Determine the workdone is an isothermal process, when the magnetization changes from M_1 to M_2. What would be the workdone, if Temperature varies from T_1 to T_2 and the magnetic field intensity is constant? 8

UNIT - II

3 a. Define first law of thermodynamics for a system;
i) Undergoing a complete cycle
ii) Undergoing a process and show that internal energy in a property of the system 10

b. Define the following terms :
i) Specific heat at constant volume and constant pressure ii) Enthalpy iii) PMMI 8

c. The work and heat transfer per degree of temperature change for a system executing a non-flow process are given by, $\frac{\delta W}{dT} = \frac{1}{30} kJ/°C$ and $\frac{\delta Q}{dT} = \frac{1}{10} kJ/°C$. Find the change in internal energy of a system as its temperature increases from 125°C to 245°C. 2

4 a. Establish the equivalence of Kelvin-Plank and Clausius statements. 8

b. What are the causes of irreversibility of a process? Explain with examples. 8

c. A domestic food freezer maintains a temperature of –15°C. The ambient air temperature is 30°C. If heat leaks into the freezer at the continuous rate of 1.75 kJ/s, what is the least power necessary to pump this heat out continuously? 4

UNIT - III

5 a. Explain the following for the pure substance with :
i) P-T diagram ii) T-V diagram iii) Mollier chart 6

Contd…2

b. A vessel of volume 0.04 m^3 contains a mixture of standard water and saturated steam at a temperature of 250°C. The mass of the liquid present is 9 kg. Find the pressure, the mass, the specific volume, the enthalpy, the entropy and the internal energy. 8

c. Why cannot a throttling calorimeter measure the quality, if the steam is very wet? How is the quality measured? Explain. 6

6 a. Write the equation of state for a perfect gas and mention what each term stands for? 6

b. A Mass of 0.25 kg of an ideal gas has a pressure of 300 kPa, a temperature of 80°C and a volume of 0.07 m^3. The gas undergoes an irreversible adiabatic process to a final pressure of 300 kPa and final volume of 0.10 m^3, during which the workdone on the gas is 25 kJ? Evaluate the C_P and C_V of the gas and the increase in entropy of the gas. 6

c. A mass of air is initially at 260°C and 700 kPa and occupies 0.028 m^3. The air is expanded at constant pressure to 0.084 m^3. A polytrophic process with n = 1.50 is then carried out, followed by a constant temperature process which completes a cycle. All the process are reversible; 8

i) Sketch the cycle in the P-V and T-S planes

ii) Find the heat received and heat rejected in the cycle

iii) Find the efficiency of the cycle

UNIT - IV

7 a. Explain with P-V and T-S diagram, the principle of working of; 6

i) Reheat Rankine cycle

ii) Regenerative Rankine cycle

b. Explain clearly the effect of pressure and temperature on Rankine cycle performance. 6

c. Steam at 20 bar, 360°C is expanded in a steam turbine to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into boiler. 8

i) Assuming ideal processes, find per kg of steam of network and the cycle efficiency

ii) If the turbine and the pump have each 80% efficiency

Find the percentage reduction in the network and cycle efficiency.

8 a. Define Air standard efficiency. Derive an expression for air standard efficiency of diesel cycle with usual notations representing the same on P-V and T-S diagram. 10

b. In a constant volume Otto cycle, the pressure at the end of compression is 15 times that at the start, the temperature of air at the beginning of compression is 38°C and maximum temperature attained in the cycle is 1950°C. Determine; 10

i) Compression ratio ii) Thermal efficiency of the cycle iii) Workdone, $\gamma = 1.4$

UNIT – V

9 a. Derive the thermal efficiency by representing schematic diagram of an ideal Brayton cycle. 8

b. Air enters the compressor of a gas turbine plant operating on Brayton cycle at 101.3 kPa, 27°C. The pressure ratio in the cycle is 6. Calculate the maximum temperature in the cycle and the cycle efficiency. Assume $W_T = 2.5\ W_C$, $\gamma = 1.4$. 6

c. List the methods for important of thermal efficiency of open cycle gas turbine plant. Explain Intercooling. 6

10 a. Derive with usual notations the expression for the workdone by a single stage reciprocating compressor with and without clearance volume. 10

b. A double acting compressor with piston displacement of 0.04 m^3 per stroke operates at 480 rpm. The clearance is 4 percent and it receives air at 100 kPa and discharges at 500 kPa. The compression and expansion is polytropic $PV^{1.3}$ = C. Determine the power required and the air discharged in m^3/s. 10

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